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Defining Terms in Behavior Analysis: Reinforcer and Discriminative Stimulus

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Many definitions of reinforcer and discriminative stimulus found in behavioral texts include a requirement of temporal proximity between stimulus and response. However, this requirement is not consistently adopted. We present additional evidence from a questionnaire that was sent to members of the editorial boards of several behavioral journals showing that there is not universal agreement concerning the temporal parameters accepted in the definitions of reinforcer and discriminative stimulus. We suggest that the disagreement over the definitions of these essential terms ought to be at least addressed if not resolved. Because the discrepancy usually occurs when the behavior of verbal humans is at issue, we urge behavior analysts to be conservative when extending the terms reinforcer and discriminative stimulus from the behavior of nonhumans in the laboratory to human behavior where the effects of many stimuli may depend in part on sophisticated verbal repertoires.

Technical terminology is an essential tool of all sciences. As such, it serves as the medium for effective communication, teaching, and many other important activities. Scientific terms must be well-defined and used in a manner consistent with their respective definitions - imagine the problems if terms such as "voltage," "electron," or "hydrogen atom" were each defined and used in different ways. A particular scientific verbal community must police the integrity of its own vernacular. As Skinner (1957) writes, a scientific community

> conditions responses under favorable circumstances, where relevant and irrelevant properties of stimuli can be easily manipulated. To dispose of irrelevant controlling relations, it sets up new forms of response as arbitrary replacements for the lay vocabulary. (p. 419)

Thus, scientific verbal behavior differs from nonscientific verbal behavior (e.g., literary verbal behavior) in the degree of stimulus control established and maintained by the verbal community. As a result of the precise stimulus control of scientific verbal behavior, metaphorical extensions and other deviations from the controlling stimuli are minimized.

How has the behavioral community fared in the effort to ensure precise terminology? Are there precise and agreed-upon definitions, and are usages consistent with those definitions? Consider the terms "reinforcer" and "discriminative stimulus," two of the essential and most frequently used terms in the vernacular. The definition of reinforcer usually comprises

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two elements: (1) a stimulus that follows behavior and (2) results in an increase in the probability of that behavior (e.g., Fantino & Logan, 1979, p. 82; Morse, 1966, p. 53; Reynolds, 1975, p. 9). Discriminative stimulus is also typically defined by two characteristics: (1) a stimulus in whose presence a response is highly probable (2) because in the past, that response has been differentially reinforced in the presence of the stimulus (e.g., Reynolds, 1975, p. 6). It would seem that such essential and often used terms would have precise and agreed-on definitions.

However, we have come to the conclusion that there is not universal agreement on a fundamental issue pertaining to both "reinforcer" and "discriminative stimulus," namely, the temporal relationship between the respective stimulus and behavior. For some behavior analysts, classifying a stimulus need not consider the temporal proximity between the stimulus and the behavior it affects. For example, if completing a tax form in a timely manner is shown to be strengthened by a sizeable refund two months later, then the refund can properly be classified as a reinforcer. For others, however, reinforcers follow behavior closely in time, and therefore a functional relation between behavior and a delayed consequence cannot be appropriately labelled as an example of simple reinforcement.

To what extent is there disagreement on this issue? Or is it even important? One way to discover how a particular discipline defines its basic terms is to sample textbooks in the field. A comparison of well-known textbooks in behavior analysis shows that the definitions of reinforcer and discriminative stimulus differ with respect to the specification of temporal parameters.

Definitions of Reinforcer

In some texts, the definition of a reinforcer does not specifically stipulate temporal contiguity between behavior and a consequence. For example:

> If the appearance of a stimulus as a consequence of a response results in an increased probability that the response will reoccur in the future, the stimulus is called a *positive reinforcing stimulus.* (Reynolds, 1975, p. 9)

> Reinforcement refers to the occurrence of a "reinforcing stimulus" or "reinforcer" defined as any event that increases the probability that the behavior it follows will recur in the future. (Fantino & Logan, 1979, p. 82)

Similar definitions of a reinforcer are available in Catania (1968), Skinner (1953), and Sulzer-Azaroff and Mayer (1977). In other sources, however, formal definitions insist on contiguity. For example:

> The *reinforcer or the reinforcing stimulus* is the event which increases the frequency of the performance it immediately follows. (Ferster & Perrott, 1968, p. 25)

> A positive reinforcer is any stimulus which, when presented immediately following a response, increases the rate of that response. (Powers & Osborne, 1976, p. 9)

> We have seen that the contiguity between response and reinforcer is an important requirement of the Law of Effect—whatever behavior immediately precedes reinforcement will be strengthened. (Mazur, 1986, p. 126)

> A positive reinforcer is an event which, when presented immediately following a behavior, causes the behavior to increase in frequency. (Martin & Pear, 1988, p. 30)

> Positive reinforcement occurs when a behavior is followed immediately by the presentation of a stimulus and, as a result, occurs more often in the future. (Cooper, Heron, & Heward, 1987, p. 25)

An important question, though, is what constitutes "immediate?" A few seconds? A couple of hours? A month? In describing examples of reinforcement, some authors whose definitions include response-reinforcer contiguity are willing to extend the concept of immediacy to relatively long periods of time. For example, Powers and Osborne (1976) discuss a weight-loss program wherein a new dress is contingent on reducing the number of bites of food ingested over several days; Mazur (1986) speaks of studying that is reinforced by a grade on the next day's quiz; and Cooper et al. (1987) present an example of a computer software developer receiving $10,000 for an innovation.

In a minority view, Martin and Pear (1988) submit that consequences delayed

by more than 30 seconds are unlikely to directly reinforce behavior, a position also held by Michael (1986) and Perin (1943). Martin and Pear (1988) present an example of a program that increased arriving at work on time through the use of bonuses. Despite the increase in the target behavior, the authors concluded that "the treatment was more complex than that of a positive reinforcer" and probably involved a "complex conditioning history concerning language."

Considering the above definitions of reinforcement, it is clear that authors differ with respect to their treatment of immediacy. Some make no mention of immediacy. Others do, but also present examples of human behavior in which immediacy is extended to consequences delayed by relatively long periods of time. Only a few authors attempt to distinguish the effects of consequences that follow a few seconds after behavior from those that follow hours, days, or months after the behavior.

Definitions of Discriminative Stimulus

Definitions of discriminative stimulus S^D suffer from similar inconsistencies. The experimental literature refers to temporal contiguity or overlap between an S^D and the behavior it controls; definitions typically require a higher probability of a response in the presence than that in the absence of the S^D (e.g., Catania, 1984; Mazur, 1986; Reynolds, 1975; Rilling, 1977). For example, Terrace (1966) describes an S^D as follows:

> Following discrimination training where responding occurs only in the presence of a certain stimulus, one could see a parallel between the onset of the stimulus and the occurrence of a conditioned response in both the operant and respondent cases. (p. 273)

But when discussing human affairs, and especially verbal control over behavior, temporal proximity between stimulus and response is not always honored. Sulzer-Azaroff and Mayer (1977) offer examples of instructional (S^D) control that illustrate this discrepancy. In one case, a "teacher instructs, 'Now play an A-minor chord,'" and the student immediately plays the correct chord. In another case, however, "it is agreed that 'We'll meet at 1:00 p.m.'" Assuming that the agreement is made hours earlier, the delay between the statement and the agreed-upon meeting time differs from the temporal arrangement in the first example. Skinner (1969), who classifies rules as discriminative stimuli, provides many examples in which the effects of such stimuli (e.g., proverbs, maxims, laws) are quite indirect and delayed. The point is that the effect of such stimuli may be observed many hours or days later. Thus, like definitions of reinforcement, those of discriminative stimuli also differ with respect to the element of temporal proximity. Exclusion of the temporal element seems most likely when interpreting human behavior.

In order to further assess the extent of the disagreement on this issue, we distributed a questionnaire to members of the editorial boards of several behavioral journals.

METHOD

A questionnaire was sent to each member of the editorial boards of the following journals: *The Journal of Applied Behavior Analysis* (JABA), *The Journal of the Experimental Analysis of Behavior* (JEAB), *The Behavior Analyst* (TBA), *The Analysis of Verbal Behavior* (TAVB), and *The Journal of Organizational Behavior Management* (JOBM). The questionnaire comprised two parts, one relevant to classifying reinforcers and one for discriminative stimuli. Each part presented a scenario followed by a series of questions (see Table 1). A scenario described a functional relation between a stimulus and behavior, but with a long delay between the two. Respondents were asked to classify the stimuli in question. If time delay was not a factor in classification, respondents were asked if the effects described in the scenario were dependent on verbal behavior. Finally, they were asked to comment on the extent to which time delays in general are a factor in classifying stimuli.

RESULTS

Taken together, answers to both scenarios show that a majority of, but not all,

Table 1

The questionnaire.

Scenario 1. There appears to be a functional relation between grant-writing and receipt of grant money: A researcher receives grant money six months after submitting a grant application and the time and effort spent in grant-writing subsequently increases.

1. Receipt of the money in Scenario 1 is a reinforcer regardless of the long delay between the behavior (grant-writing) and the consequence.

A. True B. False

2. Receipt of the money in Scenario 1 is a reinforcer, but its effects are dependent on verbal behavior by the researcher. (Please answer only if you responded True to question 1.)

A. True B. False

3. In general, if an appropriate functional relation between a response class and a consequence can be demonstrated, the delay between the two is irrelevant in defining the consequence as a reinforcer.

A. True B. False

4. If you answered False to question 3, how delayed can an event be and still be classified as a reinforcer?

Scenario 2. There appears to be a functional relation between an antecedent verbal stimulus and grant-writing: A researcher tells a colleague "submit a grant to NIH and you will surely be funded," and ten days later the colleague begins work on such a grant.

5. The antecedent stimulus in Scenario 2 is a discriminative stimulus regardless of the long delay between the stimulus and response. (Please disregard the problem of appropriate history.)

A. True B. False

6. The antecedent stimulus in Scenario 2 is a discriminative stimulus, but its effects are dependent on verbal behavior by the colleague. (Please answer only if you responded True to question 5.)

A. True B. False

7. In general, if an appropriate functional relation between an antecedent stimulus and a response class can be demonstrated, the delay between the two is irrelevant in defining the antecedent stimulus as a discriminative stimulus.

A. True B. False

8. If you answered False to question 7, by how long can an antecedent stimulus precede a response and still be classified as a discriminative stimulus?

respondents did not consider time delays when classifying stimuli as reinforcers or discriminative stimuli (see Table 2). For those who did not use time delay as a factor in classifying the stimuli, most suggested that verbal behavior played a role in the described effects. Those respondents who in general did consider time delay in classifying stimuli were asked to specify the temporal limits for designating stimuli as reinforcers or discriminative stimuli. Some suggested a "few seconds at most," others "not over 30 seconds." Still others submitted that such a question is an "empirical question." In general, the results for specific journals did not substantially differ, with the exception of TAVB. For this journal, time delays were deemed a factor by a larger proportion of the respondents than those of the other journals. Moreover, TAVB respondents unanimously agreed that verbal behavior contributed to both the reinforcement and discriminative effects when long delays were present. It is not clear why TAVB respondents were less willing to classify delayed events as reinforcers or S^Ds. Perhaps the editorial board of TAVB reflects similarities in training or perhaps the members are already preselected to consider the importance of verbal behavior.

DISCUSSION

Although a majority of the respondents did not consider temporal parameters in classifying stimuli, a sizable minority did. For the purposes of this paper, the essential point is that there is not universal agreement on a potentially important element in the definitions of reinforcer and discriminative stimulus, namely, the temporal delay between the stimulus and the response. There are several reasons why such disagreement should at least be addressed if not resolved. First, consistent use of fundamental concepts in any science seems essential for optimal functioning of that science; useful communication, cohesive research, and development of effective technologies hinge on consistently defined terms. This is not to say that definitions are

Table 2
The results of the questionnaire.

Question #	Journal	True		False		No Response or Other Response	
		#	%	#	%	#	%
1	JABA	17	85	1	15	2	10
	JEAB	14	74	3	16	2	10
	TBA	12	60	6	30	2	10
	TAVB	43	64	3	6	3	27
	JOBM	13	76	2	12	2	12
	Mean		69		18		13
2	JABA	13	76	2	12	2	12
	JEAB	5	36	7	50	2	14
	TBA	9	75	3	25	0	0
	TAVB	4	100	0	0	0	0
	JOBM	5	38	5	38	3	23
	Mean		60		28		12
3	JABA	15	75	3	15	2	10
	JEAB	13	68	3	16	1	6
	TBA	10	50	8	40	3	16
	TAVB	4	36	4	36	2	10
	JOBM	12	70	4	24	3	27
	Mean		62		25		13
4	"Not over 30 seconds" "Empirical question" "A few seconds at most"						
5	JABA	16	80	1	5	3	15
	JEAB	13	68	4	21	2	11
	TBA	14	70	4	20	2	10
	TAVB	5	45	3	27	3	27
	JOBM	13	76	1	6	3	18
	Mean		70		15		15
6	JABA	14	88	1	6	1	6
	JEAB	6	46	4	31	3	23
	TBA	11	79	1	7	2	14
	TAVB	5	100	0	0	0	0
	JOBM	7	54	2	15	4	31
	Mean		71		13		16
7	JABA	15	70	3	15	3	15
	JEAB	11	58	4	21	3	16
	TBA	11	55	7	35	2	10
	TAVB	5	45	3	27	3	27
	JOBM	13	76	2	12	2	12
	Mean		63		22		15
8	"Not over 30 seconds" "Empirical question" "A few seconds at most"						

or should be immutably fixed. With new developments should come refinement and extension of the vocabulary, but such changes must be logical and supported by the data-base of the science.

Toward that end, we suggest that there is good reason to consider temporal parameters in functional classifications. This is because, with both nonhumans and human infants, delays between behavior and both antecedent and consequent stimuli dramatically alter the effects of the respective stimuli (e.g., Blough, 1959; Millar, 1972; Lattal & Gleeson, 1990). Data with rats and pigeons show that temporal parameters are indeed important in establishing and maintaining a reinforcement effect (Gleeson & Lattal, 1987; Lattal & Gleeson, 1990). Although reinforcers need not immediately follow responses for acquisition to occur, there does appear to be a significant decrement in acquisition up to about 30 seconds, at least with rats and pigeons (Lattal & Gleeson, 1990; Wilkenfield, Blakely, & Poling, in press). However, the more immediate the reinforcer, the stronger (faster) the acquisition and maintenance of rate of response. The same results have been shown with human infants, except that the delay interval is much shorter. For example, Millar (1972) showed that delays of only 3 seconds were sufficient to disrupt acquisition of a hand-pulling response in 6-7 month-old infants.

The concepts of immediacy and delay with respect to consequences may be relative, that is, they may depend on other factors. For example, Lattal and Gleeson (1990) point out that, relative to very long experimental sessions, delays up to 30 seconds may not have the same effect as they would in shorter sessions. It is also possible that with no other opportunities for discrete responding within a relatively constricted experimental environment, a response that produces discrete feedback, like a key peck or a lever press, may be more easily acquired and maintained with delayed consequences. Likewise, researchers with humans have noted that such factors as age and the nature and the level of complexity of the response may contribute to the effects of delay of reinforcement (Millar, 1972). Although some may find compelling recent data with nonhumans which suggests that operant conditioning can occur with delayed reinforcement (e.g., Lattal & Gleeson, 1990; Wilkenfield et al., in press), it must be remembered that the temporal parameters are still on the order of seconds. How much the delay can be extended and still show response acquisition remains unanswered, but it is unlikely that it can be extended to hours, days, weeks, or months. On the other hand, as we have already indicated, with verbal humans, delays of days, weeks, or months seem to be commonplace. As we previously noted, even behavioral texts that specify temporal proximity in their formal definitions of reinforcer or discriminative stimulus provide examples of human behavior that are inconsistent with those definitions (e.g., Cooper et al., 1987; Mazur, 1986; Powers & Osborne, 1976; Sulzer-Azaroff & Mayer, 1977). And, as the results of the questionnaire indicate, most respondents were willing to call the awarding of the grant a reinforcer for grant-writing and the suggestion to write the grant a discriminative stimulus even though the delays were on the order of months and days respectively.

A possible solution to this definitional dilemma, and one that does not impose a priori temporal requirements on the definitions of reinforcer and discriminative stimulus, has been suggested by Catania (1984). Previously, we stated that definitions of reinforcement include two parts: (1) A stimulus that follows behavior and (2) results in an increase in the probability of that behavior. Such a definition does not directly address temporal parameters. However, Catania (1984) offers a third component to the definition, namely that the increase in response probability must have occurred because of the consequence and for no other reason. In other words, we only call something a reinforcer if it follows behavior and the behavior is strengthened because of that consequence and for no other reason. For the present purposes, Catania's appended definition is

interpreted as including any other variable that may contribute to the strengthening of behavior. Thus, the issue of temporal parameters becomes important because, as putative reinforcers are separated from behavior by longer periods of time, it is more likely that other variables may occur and contribute to the strengthening effect. And, with verbal humans, an individual's verbal behavior cannot be ruled out as a possible functional variable. Thus, in verbal humans, where delayed consequences seem to directly affect behavior, the long delays between behavior and contingent consequences make it almost impossible to exclude the possibility of numerous other events contributing to the strengthening of the behavior, not the least of which is the subject's verbal behavior.

With antecedent events, strengthening effects can also appear to be functionally similar but may be different. Thus, the strengthening effect of, "play an A-minor chord," on the behavior of playing the chord, called an evocative effect (see Michael, 1986), may be different than the strengthening effect of, "let's meet at 1:00 p.m.," on the behavior that results in getting to the meeting. If we assume that the statement was made at 8:00 a.m., then are we really justified in calling it an S^D for the behavior of getting to the meeting at 1:00 p.m.? Remember that most formal definitions of the S^D state that probability of behavior is greater in the presence than it is in the absence of the S^D. Such stimuli are said to "occasion" (Catania, 1984) or to "evoke" (Michael, 1983) the relevant behavior. In either case, we generally refer to "an immediate but momentary change in behavior" (Michael, 1983, p. 19) due to a special history of differential reinforcement. Is it then proper to say that the suggestion to write a grant or to meet at 1:00 p.m. "occasioned" or "evoked" the relevant behavior? And, do we know that the functional relation between the antecedent events and the behavior is due only to a history of differential reinforcement? Are we justified in accepting the notion that S^Ds can be temporally removed from the behavior which they occasion?

As a possible solution to the definitional problems of the S^D, then, perhaps we can ammend the definition of the S^D in a manner similar to Catania's refinement of the definition of reinforcement. As we stated previously the definition of S^D typically consists of two parts: (1) a stimulus in whose presence a response is highly probable (2) because in the past, that response has been differentially reinforced in the presence of the stimulus (e.g., Reynolds, 1975, p. 6). The addition would be that the increase in response probability must have occurred because of the stimulus and the history of differential reinforcement, and for no other reason. In other words, we would only call something an S^D if it evokes the behavior in question because of a history of differential reinforcement (Michael, 1980). The point of the present paper is that, with verbal humans, when stimuli with the support of a verbal repertoire affect behavior, classifying them simply as "reinforcers" or "discriminative stimuli" may miss other processes that could be involved. In short, some characteristics unique to verbal behavior may be left out of the explanation of the observed effects.

Thus, a second reason to resolve the definitional problems addressed in this paper is that it might help to elucidate the role of verbal behavior in the control of other behavior. In verbal humans, temporally distal antecedents and consequences apparently do affect behavior. Perhaps humans can be directly affected by distal events, and increasing delay does not have the devastating effect on behavior that it does with nonhumans. Or perhaps distal events affect behavior only through the mediation of verbal behavior. Unfortunately, the direct effects of delays between antecedents and behavior, as well as between behavior and consequences, have not yet been systematically researched in verbal humans. Basic facts about the effects of delays arise predominantly from nonhuman research (e.g., Blough, 1959; Lattal & Gleeson, 1990), and the addition of facts generated from human research would therefore be wel-

come. Toward that end, it would be interesting to replicate with nonverbal or preverbal humans the recent research by Lattal and Gleeson (1990) and Wilkenfield et al. (in press) examining the effects of delay of reinforcement on the acquisition of operant behavior. Existing research with preverbal humans suggests that the delays might be very short indeed (e.g., Millar, 1972). Similar research on delay gradients with S^Ds would also be helpful. Perhaps more importantly, if the role of verbal behavior could be clarified, this might go a long way towards explaining how temporally distal events affect human behavior. For example, research in so-called correspondence training has shown that some prior verbalization (either by a child or by the experimenter) is the critical variable in predicting the occurrence of future behavior. And, moreover, a child's verbalization (i.e., a promise to perform some future behavior) is no more effective than the experimenter's verbalization (i.e., the instruction to perform the behavior) in predicting whether the behavior will occur or not (Baer, Detrich, & Weninger, 1988). For example, the experimenter's instruction, "Today you need to play with the ____ if you want to get the treat" (Baer et al., 1988), is functionally related to the subsequent behavior of playing with the particular toy. For the purposes of the present paper, the question is whether this functional relation should be classified as discriminative. Although some might be willing to refer to such relations as discriminative, the position in the present paper is one of caution. If verbal behavior is involved in a given effect, then simply classifying the process as a direct discriminative or reinforcement effect may miss the operation of an important, and possibly unique, human variable. In fact, some researchers in the correspondence area have speculated that the effect of correspondence training in which the experimenter states a rule and then reinforces the child's "correspondence" behavior is that the child may have constructed his or her own "rule" describing the behavior and the outcome (e.g., Baer et al., 1988; Deacon & Konarski, 1987). If an apparent discriminative or reinforcement effect is mediated by verbal behavior, then such behavior should be afforded a prominent status if a full, compelling account of behavior is to be provided. Some behavior analysts have attempted theoretical analyses of so-called rule-governed behavior (e.g., Cerutti, 1989; Schlinger & Blakely, 1987; Blakely & Schlinger, 1987). However, an experimental analysis of such behavior is still called for. Perhaps only then will the problem concerning the disagreement over the role of temporal parameters in the definitions of "reinforcer" and "discriminative stimulus," especially regarding human behavior, move closer to resolution.

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